

What is claimed is:

1. A method of manufacturing a capacitor, the method comprising:  
forming a lower metal electrode of a capacitor;  
performing a primary wet treatment on the surface of the lower metal electrode to  
5 remove unwanted surface oxides from the surface of the lower metal electrode;  
performing a secondary wet treatment on the surface of the lower metal  
electrode by using a different etchant than an etchant used in the primary wet treatment  
to remove unwanted surface organic materials from the surface of the lower metal  
electrode;  
10 forming a dielectric layer on the lower metal electrode using a high-k dielectric  
material; and  
forming an upper metal electrode on the dielectric layer.

2. The method of claim 1, wherein the lower metal electrode is formed of one  
15 selected from the group consisting of titanium nitride, tantalum nitride, tungsten nitride,  
platinum, and ruthenium or a combination thereof, and wherein the upper metal  
electrode is formed of one selected from the group consisting of titanium nitride,  
tantalum nitride, tungsten nitride, platinum, and ruthenium or a combination thereof.

3. The method of claim 1, wherein the lower metal electrode and the upper  
20 metal electrode are formed of titanium nitride.

4. The method of claim 1, wherein the primary wet treatment is performed  
using an etchant containing one selected from the group consisting of HF, LAL, and  
25 SC1, or a combination thereof.

5. The method of claim 1, wherein the secondary wet treatment is performed  
using an etchant containing  $H_2SO_4$ .

6. The method of claim 5, wherein the etchant containing  $H_2SO_4$  used for the  
30 secondary wet treatment further contains  $H_2O_2$ .

7. The method of claim 1, wherein the secondary wet treatment is performed using an etchant containing ozone water.

5 8. The method of claim 1, wherein the primary wet treatment is performed using an etchant containing one selected from the group consisting of HF, LAL, and SC1, or a combination thereof, and the secondary wet treatment is performed using an etchant containing ozone water.

10 9. The method of claim 1, wherein the primary wet treatment is performed using an etchant containing LAL, and the secondary wet treatment is performed using an etchant containing  $\text{H}_2\text{SO}_4$ .

15 10. The method of claim 1, wherein the primary wet treatment is performed using an etchant containing SC1, and the secondary wet treatment is performed using an etchant containing  $\text{H}_2\text{SO}_4$ .

11. The method of claim 10, wherein the SC1 is used as the etchant at a temperature ranging from about 30 °C to 50 °C.

20 12. A method of manufacturing a capacitor, the method comprising:  
forming a lower metal electrode of a capacitor;  
performing a primary wet treatment on the surface of the lower metal electrode;  
performing a secondary wet treatment on the surface of the lower metal  
25 electrode using an etchant containing LAL;  
performing a third wet treatment on the surface of the lower metal electrode using an etchant containing ozone water;  
forming a dielectric layer on the surface of the lower metal electrode using a high-k dielectric material; and  
30 forming an upper metal electrode on the dielectric layer.

13. The method of claim 12, wherein the lower metal electrode and the upper metal electrode are formed of titanium nitride.

5 14. The method of claim 12, wherein the forming of the lower metal electrode comprises:

forming a molding layer;

forming a mold having a recess by patterning the molding layer;

10 forming a lower metal electrode layer having a recess along an inner surface of the recess of the mold;

forming a sacrificial layer to fill the recess of the lower metal electrode layer;

forming a lower metal electrode by separating the lower metal electrode layer by planarizing the sacrificial layer and the lower metal electrode layer until the top surface of the mold layer is exposed; and

15 selectively removing the remaining sacrificial layer.

15. The method of claim 14, wherein the separation of the lower metal electrode layer comprises planarizing the lower metal electrode layer using chemical mechanical polishing.

20 16. The method of claim 12, wherein the primary wet treatment is performed for about 1 minute to 10 minutes using as an etchant a HF diluted with deionized water in a ratio of 1: 200.

25 17. The method of claim 12, wherein the secondary wet treatment is performed for about 5 seconds to 50 seconds.

18. A method of manufacturing a capacitor, the method comprising:  
forming a lower metal electrode of a capacitor;  
30 performing a primary wet treatment on the surface of the lower metal electrode using an etchant containing HF;

performing a secondary wet treatment on the surface of the lower metal electrode using an etchant containing LAL;

performing a third wet treatment on the surface of the lower metal electrode using an etchant containing  $\text{H}_2\text{SO}_4$ ;

5 forming a dielectric layer on the lower metal electrode using a high-k dielectric material; and

forming an upper metal electrode on the dielectric layer.

10 19. The method of claim 18, wherein the lower metal electrode and the upper metal electrode are formed of titanium nitride.

20. The method of claim 18, wherein the third wet treatment is performed using the  $\text{H}_2\text{SO}_4$ -containing etchant further containing  $\text{H}_2\text{O}_2$  at a temperature ranging from about 70 °C to 90 °C.

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